

**The Economic Costs of Critical Habitat Designation:
Framework and Application to the Case of California Vernal Pools**

by

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for

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Executive Summary

This study develops a framework for measuring the economic impacts of critical habitat designation. The method developed in the paper can be applied to a number of private sector activities, including construction of homes, commercial buildings, retail centers, vineyards, and mines. The costs of designation are shown to be borne largely by consumers, with developers, landowners and others suffering losses as well.

Critical habitat designation adds a layer of regulation to the process of land development. There are several implications of this extra regulation:

- Designation increases the cost of development by requiring the developer to consult with the federal government and negotiate a permit.
- Designation can reduce the size of a project as more land is set aside for the species of concern.
- By increasing costs and reducing output, designation can raise the price of homes, shopping centers, office space and other project outputs. These price increases cause potentially large losses to consumers.
- Designation can delay completion of the project, resulting in losses to potential buyers who must wait to use the project's output.

The framework developed in the study is built on a number of stylized facts about the land development process. In particular, the framework recognizes that

- Development is subject to multiple, uncoordinated regulatory processes
- CHD can be a “signal” that increases the cost of other regulation
- There are numerous physical constraints on site selection
- Development is sequential in space and with regard to the regulatory “queue”

Taken together, these observations imply that while an area may appear to have an ample supply of developable land, in reality the development process is constrained and CHD can have an effect on the stock of housing and other projects. CHD can change the equilibrium price of housing and other real estate.

Another implication of the analysis is that by reducing the density of development in areas deemed to be critical habitat, designation can change the shape of urban areas and squeeze growth into more remote locations. This effect of designation is costly for potential homebuyers and business owners as they are forced to locate to less desirable areas with higher transportation costs. By encouraging sprawl, critical habitat designation can also lead to regional problems of road congestion and air pollution, in addition to the problem of housing affordability already mentioned.

The model is compared to the method currently used by Fish & Wildlife Service consultants to estimate economic impacts of critical habitat designation for California vernal pools. We conclude that the Service's consultants consider only some of the impacts calculated by our method and their approach is very likely to underestimate the true impacts of critical habitat designation.

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About the California Resource Management Institute

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The Economic Costs of Critical Habitat Designation: Framework and Application to the Case of California Vernal Pools

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I. Introduction

Section 4 of the Endangered Species Act authorizes the Secretary of the Interior to take economic impacts into account when designating critical habitat. This study develops a framework for measuring such impacts, drawing on stylized facts about processes of project development and land conversion, and compares the method to the one used by USFWS consultants in a recent analysis of the costs of critical habitat designation for vernal pools. With straightforward modifications, the approach developed here can be applied to many types of private sector activities affected by critical habitat designation, including home building, commercial development, mining, vineyard establishment and others.

The most obvious economic effects of critical habitat designation (CHD) are to increase the cost of development by making it more difficult to obtain necessary permits and to reduce the size of individual projects (e.g., number of single-family housing units, office spaces, etc.). However, the economic effects of CHD go well beyond these costs. The process of land development is complex and conditioned by numerous factors. If there are fewer units built as a result of CHD or if the consultation process triggered by CHD raises the cost of completing the project, then there may be market effects resulting from designation. Other land cannot always be brought into production to make up for

losses due to CHD, and even if it can, it may be in a suboptimal location. Of course, if CHD raises the price of housing, lower-income families bear the brunt of this impact.

Another important effect of CHD is to delay the completion of projects. This aspect of regulation is often overlooked by analysts, but practitioners know its importance. Delay increases carrying costs and imposes additional cost burdens on developers. The largest impact of delay, however, is on consumers who must wait to receive the benefits of the project.

CHD can also have important regional impacts. If the result of designation is to raise the cost of projects and to reduce output in areas deemed to be critical habitat, then it is important to ask whether some development is relocated to other areas. It is likely that one effect of CHD is to increase the amount of development occurring in more remote locations as developers are forced to turn to available land to meet regional needs for housing, office space and other amenities. By changing the configuration of urban areas and forcing development away from the city center, CHD can contribute to regional problems of increased road congestion, sprawl and air pollution. The negative, indirect effects should be included in an economic analysis of CHD.

The remainder of the paper is structured as follows. In the following section we review some stylized facts about the land development process. In Section III, we present a model of the economic impacts of CHD. Section IV discusses the method used by the USFWS' consultants to estimate the economic impacts of CHD for vernal pools and contrasts it to the method used by the Service's consultants. Concluding comments are contained in Section V.

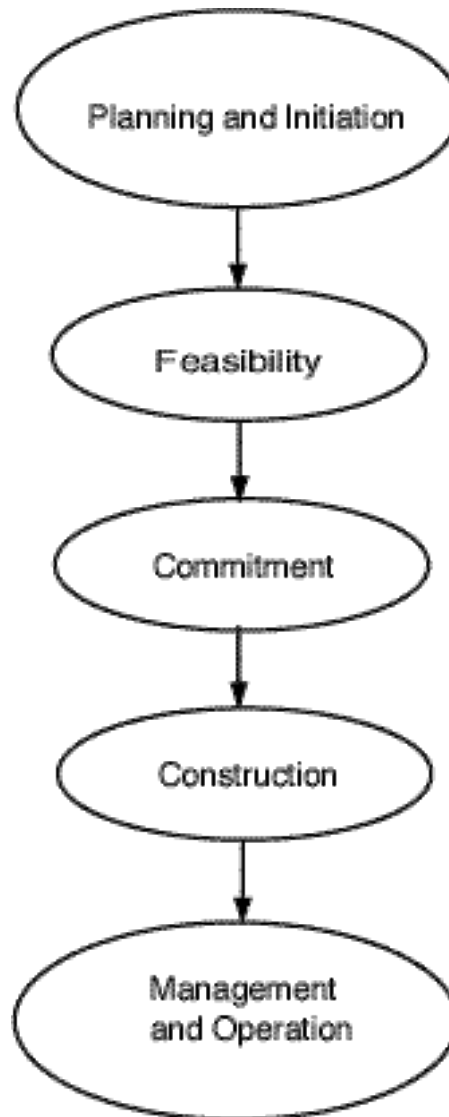
II. The Development Process and Implications for Analysis of the Costs of CHD

The process of real estate development is highly variable and project-dependent. Nonetheless, it can be divided into several phases shown in Figure 1, bearing in mind that these are only general patterns. These basic steps apply to development of single-family housing, office buildings, shopping centers and other private sector projects that are the subject of this report. Similar steps apply to agricultural and natural resource projects like vineyard establishment.

In the planning and initiation phase, the development team is assembled, major hurdles are identified and overall project objectives are assessed. Next, the feasibility of the project is considered through an assessment of market conditions, local and regional governmental objectives, availability and cost of financing, and potential project sites. Typically, land will be optioned by the end of this phase at the latest. The commitment phase of the development process involves land assembly, preparation and negotiation of environmental documents, assembly of materials needed for other regulatory approvals, preparation of documents needed for financing, and finalizing the design of the project. This phase culminates when the developer obtains the needed financing and regulatory approvals. The developer then moves on to construction and operation of the project.

Figure 1

The Development Process



Source: Peiser, 1992.

Real estate development is a complex undertaking and economic analysis of the effects of CHD must reflect some basic features of this process. Some of these realities include the following:

- Development is subject to multiple, uncoordinated regulatory processes

- CHD can be a signal that increases the cost of local regulation
- There are numerous physical constraints on site selection
- Development is sequential in space and with regard to the regulatory queue
- Project delays can be very costly to developers, consumers and others
- Development process requires sufficient financial and human capital

We will discuss each of these factors in turn, emphasizing how they affect economic analysis of CHD.

Development is subject to multiple, uncoordinated regulatory processes

While the subject of this study is CHD, a federal environmental regulation, a salient fact about the land development process is that it is the subject of a complex web of federal, state and local regulation. These processes are largely uncoordinated and have differing objectives, but they are interrelated in that the outcome of one permitting process can reverberate through the others. One dimension of this interrelation is that if the outcome of federal regulation is to reduce the size or configuration of a housing project, for example, this modification will require the developer to alter the application to the local agency. Another dimension of this interrelation is that findings from one process can influence decision-making in others.

A consistent observation of the developers who were interviewed as part of this study is that once land is labeled as critical habitat, all environmental permitting processes become more onerous. An important implication is that CHD can impose significant costs on development even if the project has no federal nexus and no Section 7 consultation is required.

Public decision makers take into account the impact of the regulation on various constituencies, including environmental groups, homeowners, local businesses, landowners, developers and government agencies. Agencies differ according to the weights given to various groups' preferences. In general, federal agencies like the Army Corps of Engineers and the Fish & Wildlife Service are less likely to consider non-environmental factors and are less certain in their requirements from the applicant's point of view. Local agencies, by contrast, are more likely to balance economic factors with environmental impacts.

Another aspect of coordination is that land can be subject to multiple environmental regulations, even multiple CHDs. The cumulative effect of multiple environmental regulations is likely to be larger than the sum of individual effects. Unless habitat associations are perfectly correlated across species or targeted amenities, adding regulations increases the amount of land set aside for mitigation and increases permitting costs.

CHD can be a signal that increases the cost of local regulation

Any designation at the federal level may affect the treatment at the local level by a signaling effect. Regulators operate under uncertainty about the value of land in different uses and may be risk-averse. Any negative designation may raise a flag about potential environmental impacts of development and lead the local agency to take a more conservative perspective on the development project. The response of local agency to CHD may vary depending on local sensitivities to environmental protection and economic development, as well as the extent of knowledge on the part of local agencies

and the public. This way of thinking about the signaling effect of CHD leads to some interesting predictions:

- The less informed the local agency is about the local environment, the more likely CHD is to increase the difficulty of permitting.
- The more emphasis the locality places on environmental protection versus economic development, the stronger the impact of CHD on local approval.
- The higher is the actual risk posed by development, the stronger is the impact of CHD.
- CHD has an economic cost even on lands with no federal nexus. CHD may affect severity of treatment and delay approvals at the local level. The delay effect will be larger in cities and counties with a more constrained permitting capacity.

There are numerous physical constraints on site selection

Site selection can occur before or after the developer evaluates local market conditions. This process is often exhaustive since a large number of factors are relevant to the site selection process. In fact, the National Association of Home Builders has developed a list of over 1,000 factors that should be considered before acquiring land for development. Among the factors that make a site suitable for development are the following:

- Location and neighborhood
- Size and shape
- Accessibility and visibility
- Environmental conditions

- Legal constraints
- Utilities
- Zoning and regulation

The cumulative effect of these factors is that while an area may appear to have a large amount of vacant land available for development, in reality there can be little land actually or realistically available for development. Imposing additional regulation through CHD may effectively reduce the amount of land available for development in a region, reduce the regional stock of housing and other goods and create unintended consequences on other resources (such as agriculture) and local planning processes.

Development is sequential in space and with regard to the regulatory queue

Other factors constrain the development process. Leapfrog development is increasingly problematic since local governments often seek to confine development within defined boundaries. Further, non-sequential development requires utilities, roads and other infrastructure to be extended longer distances, thereby increasing project costs. Thus, land away from the urban boundary may be at best an imperfect substitute for land on the boundary that is set aside for habitat protection.

Local governments have limited capacity to process permit applications and consider them in the sequence they would like the area to evolve. Developers interviewed as part of this study all recalled instances where they were forced to wait long periods, in some cases several years, for a local government to work through its backlog of applications for projects that were closer to the city center.

Project delays can be very costly to developers, consumers and others

Regulation can significantly delay completion of a project, imposing potentially large costs on the developer, consumers and others affected by project completion. This aspect of CHD should be included when calculating its economic impact.

Consider the costs of delay on one component of land development expense: the cost of acquiring land. The developer typically acquires land for the project in three steps: a “free-look” period, a period in which the developer has locked up the land with an option to purchase, and closing. Developers usually acquire an option to purchase fairly early on in the process.

Table 1 shows how the development process can be affected by environmental regulation. In this stylized example prepared by the Urban Land Institute, the developer acquires an option near the start of the development process, only one month after initiation (even before performing a market analysis). The developer must then pay to maintain this option until all regulatory approvals are obtained. In areas like California where land is expensive, delay can significantly increase development costs.

The ultimate decision to assemble land and construct a project is the result of many factors. Figure 2 shows some of the interrelated processes that feed into the “go/no go” decision. If environmental regulation requires a redesign of the project or simply delays receipt of needed permits, overall project costs can increase significantly. For example, if environmental regulation reduces the number of allowable units in a project, then the developer may need to redesign the entire project, reconsider the financial analysis and rework financing.

Table 1

Typical Months Elapsed for a Small Office or Apartment Building

	Stage of Development	Area with Few Regulations	Area with Many Regulations
1.	Earnest Money Contract Signed	0	0
2.	Earnest Money Committed	1	1
3.	Market Study	2	2
4.	Preliminary Design	3	3
5.	Engineering Studies	6	6
6.	Approvals ^a	6	24-60 ^b
7.	Financing Commitment	6	24-60
8.	Working Drawings and Building Permits	9	27-63 ^c
9.	Land Purchase and Construction Loan Closed ^d	9	27-63

^aAssuming no zoning changes are necessary.

^bEnvironmental, political, design review, and other approvals can take two to five years.

^cBuilding permits can take six to nine months after working drawings are finalized.

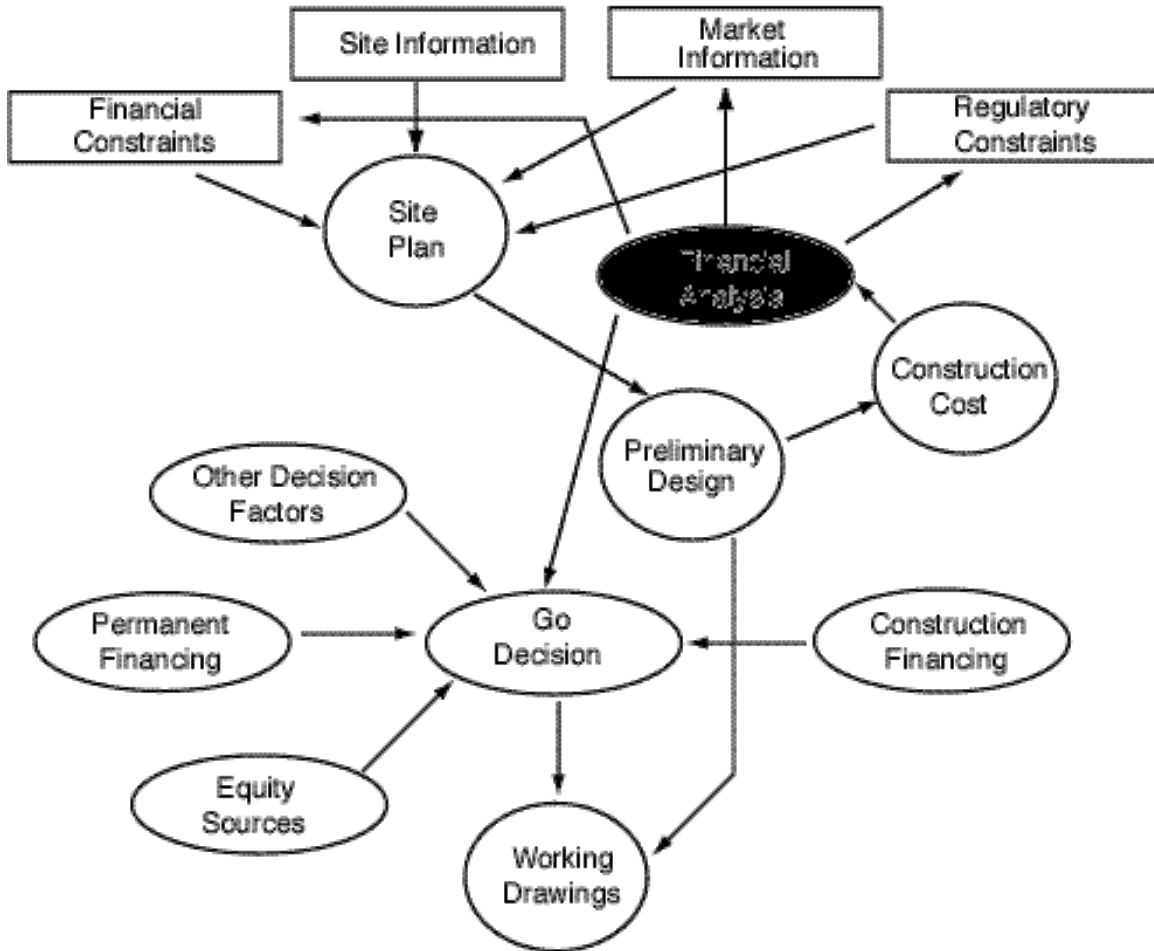
^dMost sellers require closing on the land sooner than nine months, but the deal should not be finalized without tentative financing commitments and approvals in place.

Source: Urban Land Institute, 1989.

Beyond increasing development costs, delay can reduce societal benefits from development in other ways. One obvious effect is that delay reduces the present value of development by pushing consumption further into the future. Thus, delay reduces the present value of the developer's return on investment and the final consumers enjoyment of the product. In extreme cases, delay can lead to bankruptcy if the developer is highly leveraged. Delay may also lead to relocation of key industries away from the region as they search for needed facilities. Delay can also increase the costs of related infrastructure development – cost often borne by cities or counties.

Figure 2

The Decision to Develop



Source: Peiser, 1992.

Implications of the stylized facts

Taken together, these observations imply that while an area may appear to contain an ample supply of developable land, in reality the development process is constrained and CHD can have an effect on the stock of housing and other projects. CHD can change

the equilibrium price of housing and other real estate (e.g. business parks, warehouses and shopping centers). To summarize:

- CHD increases development cost and reduces the size of affected projects.
- Because the number of suitable sites is limited, CHD reduces the size of regional housing stock and other amenities.
- CHD changes the configuration of cities, squeezing development out of some areas and toward more remote locations, resulting in increased commute costs, sprawl and other problems.
- Projects can be delayed by CHD, resulting in increased development costs and other effects.
- The impacts of CHD go well beyond the developer and landowner to include current and prospective homebuyers, commuters, local government and others.

III. Framework for Measuring the Economic Costs of CHD

In this section, we develop an economic framework to measure the impacts of critical habitat designation. We consider a situation in which some part of a region is designated as critical habitat. The most obvious effects of designation are to increase the cost of development and to reduce the size of completed projects, even if the project is not subject to Section 7 consultation. Following the discussion above, however, we also consider designation within a dynamic framework and measure the costs of project delays. We also suggest ways to measure market effects, and the regional and indirect costs of designation.

Our formulation envisions that development proceeds sequentially and is affected by topography, the location of necessary infrastructure, and by the preferences of local governments to accommodate economic development and reduce transportation cost. We consider “greenfield” development that aims to convert raw land at the urban fringe to some other use.

Impacts of Reduction in the Amount of Development

Our initial analysis is a regional general equilibrium framework, and borrows much from the traditional approach of environmental economics. Some of the explicit dynamic elements of the model will be added in later work.

Let the quantity of development at some location be denoted as Q . The curve $D(Q)$ in Figure 3 denotes the value of the Q th unit of development to its buyer. The value of each unit of development represents the expected discounted (present value) benefit of the project over time, and in the maximum amount a buyer will be ready to pay for the

Q th unit of development. The curve is negatively sloped and the incremental benefit of development to consumers is declining.

Local authorities are assumed to take into account both private and local public costs of development as well as the benefits of development, and are assumed to operate under some capacity constraints in terms of their ability to process development applications. Local authorities determine Q_0 , the benchmark level of development, defined as the amount of development that would have occurred without CHD. As shown in Figure 3, one plausible explanation for Q_0 is that it is determined when $SMCO(Q)$, a curve representing the social marginal cost of regulation (excluding costs associated with CHD), intersects the demand curve. But we will not make this assumption explicitly and instead take Q_0 as given. The developer may have market power and the unrestricted equilibrium may be smaller than at Q_C (when $MC = 0$). But the private optimum without regulation will be greater than Q_0 .

Figure 4 shows the effects of critical habitat designation on the development equilibrium. The curve $MC_0(Q)$ denotes the marginal private cost of development prior to designation. We expect this cost to increase as a result of CHD. Critical habitat designation will increase the marginal cost of development to $MC_1(Q)$ and reduce the amount developed to Q_1 . Equilibrium price increases from P_0 to P_1 .

Figure 3

Pre-Regulation Equilibrium

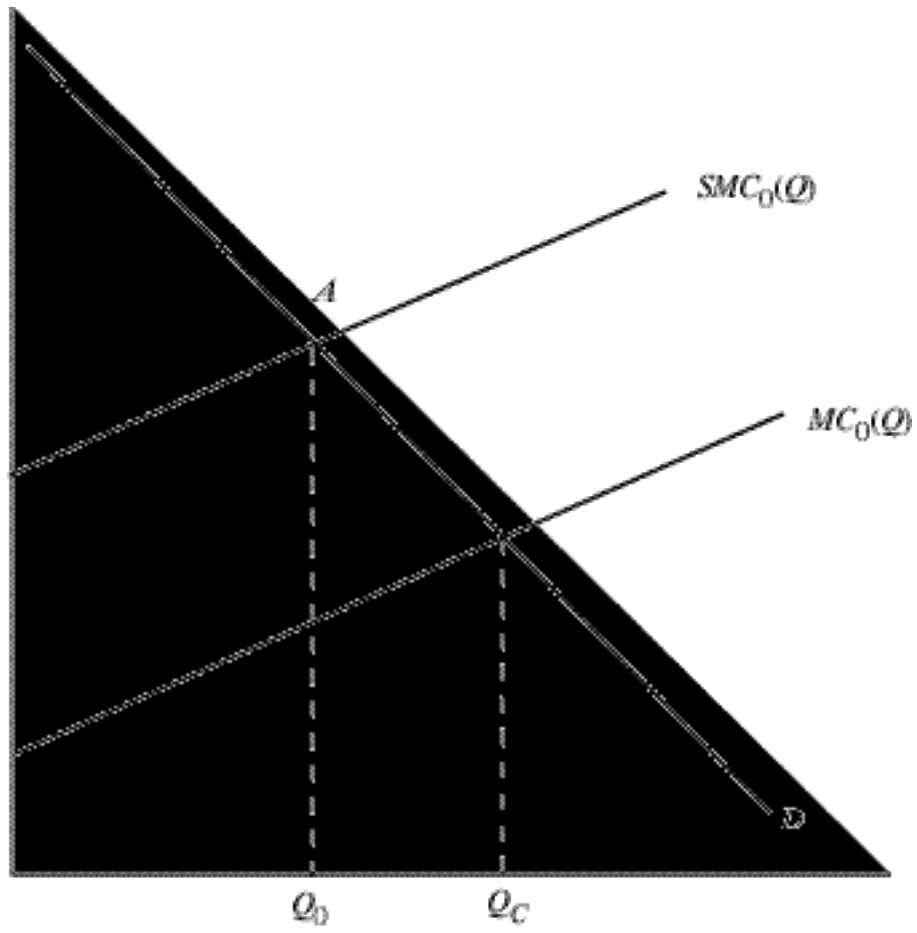
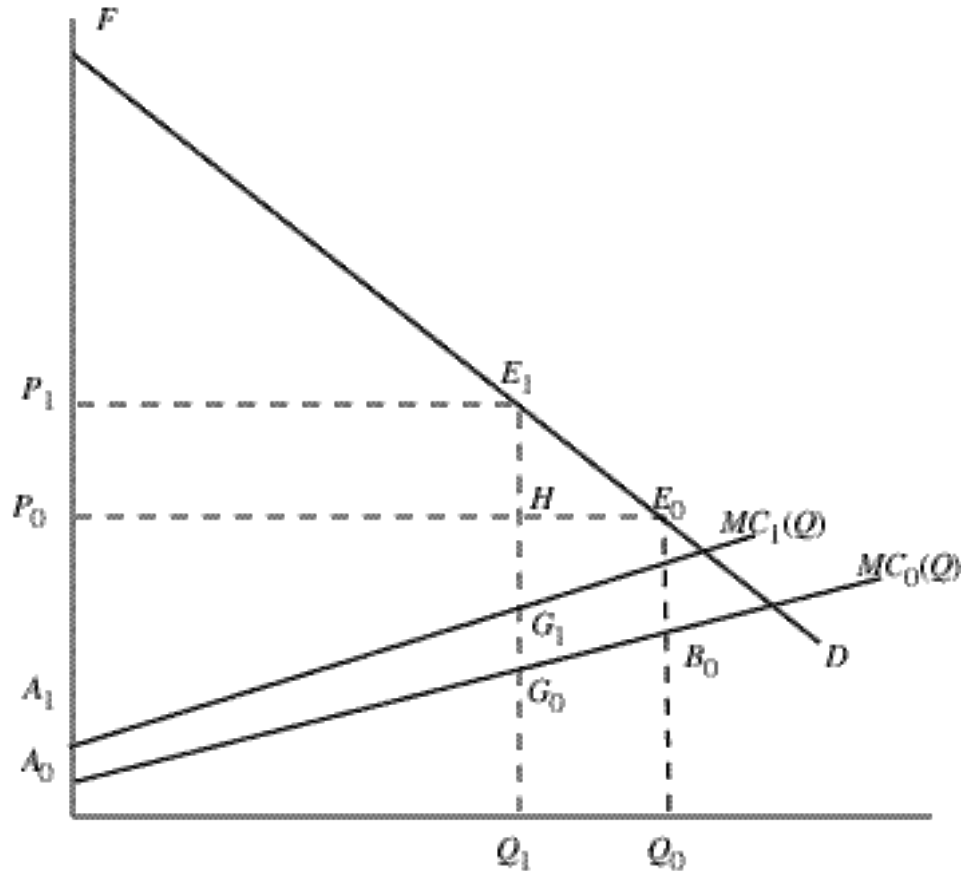


Figure 4

Market Effects of Critical Habitat Designation



Consumers' net benefit from development, represented by their consumer surplus, is the difference between their gross benefit from development (the area under the demand curve) and the price they pay. Then the area FP_0E_0 represents consumer surplus under the benchmark case. Producer surplus (benefits accruing to developers and landowners combined) is the difference between their revenue and cost. In this benchmark case, producer surplus is equal to $P_0E_0B_0A_0$. The area $F E_0B_0A_0$ is total surplus (or consumer plus producer surplus) and is a measure of economic benefit from development prior to CHD.

To formalize these relationships, let $\Delta Q = Q_0 - Q_1$ be the reduction in development because of CHD. The elasticity of demand and supply at each point are

$$\epsilon_D = -\frac{\partial Q^D}{\partial P} \frac{P}{Q}$$

$$\epsilon_S = \frac{\partial Q^S}{\partial P} \frac{P}{Q}$$

where $-\frac{\partial Q^D}{\partial P}$ and $\frac{\partial Q^S}{\partial P}$ are the slopes of the demand and supply curves, respectively.

Let the increase in marginal cost per unit of development because of CHD be constant and equal to b .

The change in equilibrium quantity, price and development cost affect the surplus of various groups in the model. The change in price resulting from CHD is $\Delta P = P_1 - P_0$,

and this change can also be expressed as $\Delta P = \frac{-\Delta Q}{\epsilon_D(Q_0)}$ for some $Q < \tilde{Q} < Q_0$. For

simplicity, we will use ϵ_D for the elasticity of demand evaluated at $Q_1 < \tilde{Q} < Q_0$ in future formulations. CHD causes a larger price increase when demand elasticity is low.

Producer welfare is affected by CHD in several ways, some of which increase profit and some of which decrease it. The change in revenue resulting from CHD is

$$(1) \quad \Delta R = P_1 E_1 H P_0$$

This expression is negative if the elasticity of demand is smaller than 1 and the gain from increase in price exceeds the loss because of lower volume. The change in producer cost is

$$(2) \quad \Delta C = A_1 G_1 G_0 A_0 - Q_1 Q_0 G_0 B_0.$$

The first element is the extra cost associated with CHD, and the second element reflects the cost savings associated with smaller output. The net effect of designation on producer surplus is thus

$$(3) \quad \Delta PS = P_1 E_1 P_0 H - H E_0 B_0 G_0 - A_1 G_1 G_0 A_0$$

Using the mathematical assumptions and notation introduced earlier, ΔPS can be written as

$$(4) \quad \begin{aligned} \Delta PS &= Q_1 \frac{\Delta P}{\epsilon_D} - \Delta Q \left[P_0 - MC(Q_0) + \frac{1}{2} \frac{\Delta Q}{\epsilon_S} \right] - \beta Q_1 \\ &= Q_1 \left[\frac{\Delta P}{\epsilon_D} - \beta_1 \right] - \Delta Q \left[P_0 - MC(Q_0) + \frac{1}{2} \frac{\Delta Q}{\epsilon_S} \right]. \end{aligned}$$

Producers are more likely to lose from CHD when β (the extra per unit cost incurred from CHD) is large and when the change in output is large. If demand is very elastic and the price effect of designation is negligible, producers, that is, developers and landowners, are likely to lose because of both lower volume and higher cost. If demand is inelastic, producers actually may gain from CHD because the large price increase more than offsets the reduction in output and the increase in cost.

The impact of CHD on consumer surplus is unambiguously negative and equal to the area $P_1 E_1 F_0 P_0$ in Figure 4. Given some reduction in output caused by CHD, consumer loss is greater when demand is less elastic. Using the notation developed earlier, consumer loss from CHD is

$$(5) \quad \Delta CS = -\frac{\Delta Q}{\epsilon_D} Q_1$$

Total surplus is conventionally defined as the sum of consumer and producer surplus. The total surplus loss from CHD is

$$(6) \quad \Delta SC = E_1 E_0 G_0 B_0 + A_0 G_0 G_1 A_1$$

The first element represents loss of surplus because of reduced development and the second element represents the social costs because of CHD. The total surplus effect of

$$\text{CHD can also be expressed as } -\Delta Q \left[P_0 - MC(Q) + \frac{1}{2} \frac{\Delta Q}{\epsilon_S} \right] - Q_1 \beta.$$

The loss from reduced development increases with ΔQ and the average gain per unit of development lost is $P_0 - MC(Q) + \frac{1}{2} \frac{\Delta Q}{\epsilon_S}$. The greater the margin between price and marginal cost, the greater is this element of impact. The results above also show that the loss because of CHD is increasing the greater is the extra cost per unit of development after CHD.

The economic effects of CHD described here may also have social equity or “environmental justice” implications. Taking housing as an example, an increase in the price of housing that results from CHD implies that those with the lowest willingness to pay for housing, including those with the lowest incomes, will be priced out of the market and forced to locate in alternative areas. A related, and interesting, impact of CHD not

considered by this model is the impact of designation on the quality of housing constructed. It is much more likely that a developer will reduce the output of lower-end units in response to CHD. Thus, CHD can increase the average quality (and price) of new homes. The net result of these two types of effects is that low-income homebuyers are especially vulnerable to dislocation as a result of CHD.

Environmental Cost of Shift in Development

CHD reduces the amount of development in a particular location and forces some of the people who lost housing opportunities to relocate. The private cost of these changes may be represented by the demand for development. However, there are other social costs of reduced development that are not included in the previous analysis, for example the environmental costs of increased spread and extra travel. At least some of the people who were not able to find a place at the planned development will locate elsewhere.

Relocation of housing and other types of projects will entail increased development in other areas most likely further away from the urban center, thus potentially impacting agricultural resources or other habitat areas. Relocation also entails extra road congestion and commute distances, resulting in increased air pollution and fuel expenses. Additional development also entails extra cost in terms of planning, permitting and environmental assessment. So let EC be the environmental and other cost of CHD, and assume that cost per unit of development is V_{ec} . Thus,

$$(7) \quad EC = V_{ec} \Delta Q.$$

Delay Cost

Designation of land as critical habitat leads to delay of development activities and loss of economic benefits that could have been generated during the period of delay.

Without CHD, the economic benefits per period are the initial social surplus

$SC_0 = \text{area}(FE_0B_0A_0)$ and, if the delay is of one period of time and the interest rate is r , the delay cost is $DLC = rSC$.

To derive the market benefits of development without CHD, we need to know the initial demand for and marginal cost of development. We suppose that both can be approximated by linear functions. Let ε_{D_0} and ε_{S_0} be the elasticities of demand and marginal cost evaluated at Q_0 , respectively. The slope of the demand curve is

$-\frac{1}{\varepsilon_{D_0}} \frac{P_0}{Q_0} = b_0$ and the slope of marginal cost is $\frac{1}{\varepsilon_{S_0}} \frac{B}{D_0} = b_s$. Define MC_0 as the

marginal cost at the point $Q = Q_0$. At the initial equilibrium, $MC_0 \leq P_0$, and the larger is the margin between market price and marginal project cost, the stricter is the initial regulation.

With these definitions, we have the following definition of social surplus:

$$(8) \quad SC_0 = P_0 Q_0 \left[1 + \frac{1}{2\varepsilon_{D_0}} \right] - Q_0 MC_0 \left[1 + \frac{1}{2\varepsilon_{S_0}} \right].$$

The first element of SC_0 is the gross benefit to consumers (the area under the demand curve). The second element is development cost. The less elastic are demand and marginal cost, the greater is the market surplus from development and, thus, the cost of delay.

While delay costs per period are equal to $r \cdot SC_0$, they are shared between consumers and developers. These delay costs are benefits that are not realized because of CHD. In addition, the developer also has out-of-pocket expenditures on interest for investment in land and development efforts that may generate cash-flow problems and even result in bankruptcy.

IV. Case Study: Vernal Pools

This section describes the methods used in the creation of the *Draft Economic Analysis of Critical Habitat Designation for Vernal Pool Species* conducted by Economic & Planning Systems, Inc. (EPS) of Berkeley, CA. After detailing the procedure used by EPS to measure economic impacts, we compare this approach to our method described in the previous section. The EPS approach is seriously lacking on both conceptual and empirical grounds and underestimates true impacts by a wide margin.

Vernal pools are seasonal wetlands; by definition vernal pools are dry for part of the year, and may fill once, several times, or never, depending on the intensity and duration of the rainy season. Vernal pools occur on relatively flat lands in shallow depressions with an underlying layer of impermeable rock, usually hardpan, claypan, or volcanic basalt. This layer of rock helps keep the pool filled with water by preventing water from seeping into the ground and is crucial to the existence of vernal pools. The stochastic nature of vernal pools is important for two reasons: 1) vernal pools provide habitat to those plants and animals that have specially adapted to the extreme wet/dry cycles, making them unique ecosystems, and 2) vernal pools are difficult to accurately identify and map since they are essentially invisible during the dry part of the year.

Current estimates state that vernal pool complexes may have covered between two (Sugnet 1996) and four million acres of the California Great Central Valley (Holland 1978). Currently, there are approximately 1,016,000 million acres of vernal pool complexes over 40 acres in size (Holland 1998), of which, 94% is on privately held land. Figure 5 shows the current distribution of vernal pools within California. Many vernal pools sites are also desirable for other land uses, and indeed much of the acreage within

California that was previously considered vernal pool, has been converted to agriculture, viticulture, or urban development. With the disappearance of many of California's vernal pools, species that rely on them for habitat are also disappearing. At least 11 federally listed endangered species rely exclusively on vernal pools for habitat. Recently the U.S. Fish and Wildlife Service has designated 1.6 million acres of California and Jackson County, Oregon as critical habitat for vernal pool species.

Figure 5

Distribution of Vernal Pools in California



EPS' analysis segregates the economic impacts of CHD into two parts: i) the administrative costs of Section 7 consultations, and ii) the costs associated with project modifications as a result of meeting Section 7 requirements. Table 2 shows the distribution of the costs of vernal pool endangered species critical habitat designation estimated by Economic and Planning Systems, Inc. The Fish and Wildlife Service, through the consultation process, may require project applicants to modify the project in order to lessen the effects to the endangered species or its critical habitat. The majority of the estimated costs are attributable to modifications to private development projects, and it is estimated that over 90% of the total costs of critical habitat will be borne by private landowners. This section will first describe the methodology and assumptions employed by EPS to calculate the costs of project modifications for private landowners, the single largest expected cost of critical habitat designation, and secondly discuss the methods used to estimate the total costs of administering the Section 7.

Table 2
EPS Cost Analysis

Consultation Nexus	Administration Costs		Project Modification	Total Costs	
	Low	High		Low	High
Department of Defense	\$256,800	\$476,000	\$2,350,000	\$2,606,800	\$2,826,000
State and Local Governments	\$1,718,000	\$4,465,200	\$2,624,000	\$4,342,000	\$7,089,200
Public and Private Entities	\$182,800	\$324,600	\$0	\$182,800	\$324,600
Public and Private Utilities; Energy	\$126,000	\$271,700	\$0	\$126,000	\$271,700
Western Area Power Administration	\$53,200	\$100,800	\$0	\$53,200	\$100,800
Bureau of Reclamation	\$529,200	\$984,200	\$0	\$529,200	\$984,200
Native American Governments	\$163,300	\$265,300	\$1,266,000	\$1,429,300	\$1,531,300
Private Landowners	\$1,839,746	\$3,980,920	\$116,412,678	\$118,252,424	\$120,393,598
Fish and Wildlife Service	\$146,300	\$277,200	\$0	\$146,300	\$277,200
Forest Service	\$398,500	\$739,200	\$255,000	\$653,500	\$994,200
20 Year Total	\$5,413,846	\$11,885,120	\$122,907,678	\$128,321,524	\$134,792,798
Annualized Total	\$270,692	\$594,256	\$6,145,384	\$6,416,076	\$6,739,640

Project Modification Costs

In the EPS analysis, the largest single source of the costs created by critical habitat designation is the modification of private development projects to complete the Section 7 consultation process with the Fish and Wildlife Service. These modifications are a result of conflicts arising from the potential destruction of vernal pools for proposed developments in critical habitat areas. The development process may require the filling or dredging of a wetland, which requires a federal section 404 permit from the Army Corps of Engineers. This federal nexus makes a Section 7 consultation necessary under the Endangered Species Act. In order to gain approval and complete the Section 7 process, land developers may have to modify their development plans or take other actions to mitigate the development effects on the endangered species or critical habitat.

Project modification costs to private landowners occur either through extra costs incurred, or revenue lost as a result of Section 7 consultations. Land developers may lose revenue in instances where critical habitat designation will prevent the development of portions of land that would otherwise be developable. In addition to preventing some development, Section 7 consultations may also require developers to restore some portion of the vernal pool habitat destroyed in the development process, or even purchase off-site lands to offset lost vernal pool habitat. The total costs of project modifications to private landowners will depend on the amount of development that occurs in critical habitat areas, the mitigation requirements necessary to gain Fish and Wildlife Service approval, and the value of the lands in question.

The EPS cost estimation process can be broken into six important steps. The first step in quantifying the costs of project modifications is to determine which types of mitigation requirements will be necessary to gain Section 7 approval. Critical habitat for more frequently occurring species will require less mitigation, while development projects occurring in critical habitat areas for less frequently occurring species will require more mitigation in order to gain approval. EPS analysts categorized critical habitat areas into two groups: Group A habitat requiring less mitigation, and Group B habitat that requires more mitigation. EPS then estimates the amount of development likely to occur within critical habitat areas using a quantitative development model. These mitigation estimates are then combined with the expected costs of each mitigation process to calculate the total cost of all project modifications.

Step 1: Categorize critical habitat areas based on the mitigation necessary for Section 7 approval.

The EPS analysis categorizes the consequences of proposed development in critical habitat into two groups based on the species present. Group A Critical Habitat is proposed critical habitat that contains more frequently occurring species, while Group B Critical Habitat are the areas containing critical habitat for any of the less frequently occurring species: Butte County Meadow Foam, Colusa Grass, Conservancy Fairy Shrimp, Sacramento Orcutt Grass, or Solano Grass.

Step 2: Estimate typical mitigation measures for development projects.

This step involves two parts, 1) Estimating the amount of development allowed on the site, and 2) Estimating the amount of off-site mitigation measures.

EPS analysts use the assumption that FWS will require an avoidance to filled acreage ratio of 6:1 for Group B critical habitat areas. This means that developers will only be allowed to develop on one-seventh of their land, which EPS assumes will result in a total land value of one-seventh of the potential market land value. For Group A critical habitat areas, EPS assumes that there is no avoidance ratio required, and consequently, no loss in land value.

However, there are other mitigation costs to consider including off-site preservation and vernal pool restoration. Developers may be required purchase off-site vernal pool wetland acres to offset the acreage filled during the development project. Other types of mitigation costs include the restoration of filled vernal pools. In order to quantify the mitigation costs, EPS analysts assume that vernal pools constitute 3.5% of the total acreage of development projects. This means that for a typical 300-acre site, there will be 10.5 acres of vernal pools. EPS cites the FWS and assumes that Section 7 consultations will require developers in Group A critical habitat to purchase and preserve two acres of vernal pool habitat for every acre filled through the development process. Since Group A developers were not required to preserve any of the estimated 10.5 acres of vernal pools, they will have to purchase either 21 acres of vernal pool habitat elsewhere, or 21 conservation credits from conservation banks.

EPS assumes that developers in Group B critical habitat areas must restore filled vernal pool acres at a ratio of 3 to 1. Since these development projects were only allowed

to develop on one-seventh of the total acreage, only 1.5 acres of vernal pools (10.5/7) will be filled by development in a typical project. This means that Group B developers will have to purchase 4.5 acres of off-site vernal pool habitat or conservation credits to replace the 1.5 acres of vernal pool habitat that were filled.

Step 3: Estimate the quantity of development that is likely to occur within the proposed critical habitat areas.

EPS analysts use the California Urban and Biodiversity Analysis model (CURBA) to generate predictions of future development. The CURBA model uses Geographic Information System (GIS) data to predict the likelihood of future development for lands within the study area. It uses various types of geographic data to predict the location of development, including: “the current location and type of farmland and urban development, slope and elevation data, location of roads and hydrographic features, wetland and flood zones, proximity to jurisdictional boundaries, local growth policies, recent population and job growth, and population projects by county.” The analysts then used mapping software to determine the quantity of development likely to occur within the critical habitat boundaries. They estimate that within the next 20 years, development will occur on 23,503 acres of Group A Critical Habitat and 2,869 acres on Group B Critical Habitat areas.

EPS then assumes that only a portion of these lands will require Section 7 consultations. They estimate that 10% of the development acres will be exempt from Section 7 consultations because of “developer [ability] to modify project to avoid vernal pools,” and an additional 9% due to “certain project designs” that will not require a

Section 404 permit. This results in a final estimate of 19,038 acres of Group A and 2,324 acres of Group B Critical Habitat areas requiring Section 7 consultations. See Table 11 on pages 72-73 of the DRAFT for acreage by county.

From a practical standpoint, the effect of this analysis is to radically reduce the acreage of designated habitat that has economic impacts. Of the 1.6 million total acres of designated critical habitat, the CURBA model predicts that less than 25,000 acres will be developed over the next 20 years – of this amount, only 2,324 are Group B Critical Habitat where the largest impacts occur.

Step 4: Estimate the prices of developable land and the costs of vernal pool habitat mitigation.

EPS used RAND and the California Association of Realtors sources to estimate the relative value of developed land for each county. They also used the Sacramento Region conservation bank to estimate the per-acre cost of conservation credits, and state, “compensation costs are expected to vary in line with land value.” They assume restoration prices will always be always 12% of developed land prices and off-site preservation land prices are always 48% of developed land prices. For a complete description of estimated land prices in all 37 affected counties, see Table 12 on page 76 of the DRAFT.

Step 5: Estimate the Percentage Value Lost due to critical habitat.

EPS makes the assumption that restoration and off-site preservation costs vary linearly with land prices. In fact, since EPS also assumes that vernal pools are homogeneously distributed throughout critical habitat areas and mitigation regulations are constant within Group A and B critical habitat, EPS implicitly assumes that project modification costs are a constant percentage of the potential project value (the price of developable land times the quantity of developable land). Since restoration costs are always 12% of developable land prices and off-site preservation land prices are always 48%, and vernal pools always account for 3.5% of the total land acreage, EPS determined that development likely to occur on Group A critical habitat loses 4.48% of its potential value, and 86% if it is to occur on Group B critical habitat.

This means that the total cost of project modifications depends only on the estimated quantity of development to occur, and the value of land on which it is to occur. See the Appendix for the explicit calculations of these values.

Step 6: Calculate the total cost of project modifications by aggregating costs across all counties.

After estimating the cost of project modifications as a percentage of land value, EPS calculates the total cost of project modifications by critical habitat group for each county. They calculate the total potential value of the land expected to develop within each critical habitat group, by simply multiplying an estimate of the price of developed land by the total acres of net developable land. They then use their estimates of the

percentage value lost to total lost value in the county. They simply add the county subtotals to obtain the total cost of project modifications.

Table 3
EPS County-Specific Costs of Project Modification

County	Gross Overlap (1)		Overlap & Nexus (2)		Net Developable Land (3)		Price of Land (4)	Land Value (5), (6)		Cost Estimates (6)		
	Group A	Group B	Group A	Group B	Group A	Group B		Group A	Group B	Group A	Group B	Total
Solano	5797	701	4696	568	3522	426	\$72,782	\$256,315	\$30,995	\$11,483	\$26,655	\$38,138
Sacramento	515	688	417	557	313	418	\$52,286	\$16,358	\$21,853	\$733	\$18,794	\$19,527
Colusa	230	662	186	536	140	402	\$43,084	\$6,020	\$17,327	\$270	\$14,901	\$15,171
Merced	0	471	0	382	0	286	\$41,829	\$0	\$11,969	\$0	\$10,293	\$10,293
Butte	300	320	243	259	182	194	\$43,084	\$7,852	\$8,376	\$352	\$7,203	\$7,555
Placer	2736	0	2216	0	1662	0	\$73,201	\$121,669	\$0	\$5,451	\$0	\$5,451
Alameda	1851	0	1499	0	1124	0	\$107,500	\$120,882	\$0	\$5,416	\$0	\$5,416
San Luis Obispo	1619	0	1311	0	984	0	\$79,475	\$78,167	\$0	\$3,502	\$0	\$3,502
Shasta	2467	0	1998	0	1499	0	\$43,084	\$64,570	\$0	\$2,893	\$0	\$2,893
Monterey	828	0	671	0	503	0	\$123,813	\$62,279	\$0	\$2,790	\$0	\$2,790
Jackson OR	1289	0	1044	0	783	0	\$49,776	\$38,978	\$0	\$1,746	\$0	\$1,746
Riverside (7)	4328	0	3506	0	2629	0	\$50,613	\$133,075	\$0	\$1,380	\$0	\$1,380
Napa	287	0	232	0	174	0	\$114,193	\$19,910	\$0	\$892	\$0	\$892
Tehama	98	26	79	21	60	16	\$43,084	\$2,565	\$681	\$115	\$585	\$700
Plumas	607	0	492	0	369	0	\$31,372	\$11,569	\$0	\$518	\$0	\$518
Madera	344	0	279	0	209	0	\$28,444	\$5,944	\$0	\$266	\$0	\$266
Tulare	193	0	156	0	117	0	\$32,208	\$3,776	\$0	\$169	\$0	\$169
Yolo	0	1	0	1	0	1	\$65,253	\$0	\$40	\$0	\$34	\$34
Kings	8	0	6	0	5	0	\$32,208	\$157	\$0	\$7	\$0	\$7
Fresno	6	0	5	0	4	0	\$34,718	\$127	\$0	\$6	\$0	\$6
TOTAL	23,503	2,869	19,037	2,324	14,278	1,743		\$950,212	\$91,239	\$37,988	\$78,466	\$116,454

- (1) This value (in acres) is determined by the CURBA model
(2) This value is found by multiplying the gross overlap value by 81% to account for development that does not have a Federal Nexus
(3) This value is found by multiplying the "Overlap & Nexus" value by 75% to account for 25% of lands devoted to parks, roads, etc.
(4) This value is the average present value of the price of developable land for the county in question
(5) This value is found by multiplying the "Net Developable Land" value by the "Price of Land"
(6) These values are in \$1,000's
(7) Riverside County projects are an exception to the rule and are estimated to have only minor section 7 costs

Administration Costs of Critical Habitat Designation

To estimate the total costs associated with administering Section 7 consultations, EPS had to answer the questions: 1) What is involved in a consultation? 2) What are the costs of each type of consultation? and 3) How many of each type will occur? To answer these questions the EPS analysts relied extensively on historical data provided by the Fish

and Wildlife Service as well as data from the CURBA model used to estimate future development.

1) What is a Section 7 consultation?

A Section 7 consultation is a communication process between the Fish and Wildlife Service, a federal agency, and a third party in order to ensure that a project will not adversely affect an endangered species or its critical habitat. There are three levels of consultation, Technical Assistance, Informal Consultations, and Formal Consultations. Technical assistance refers to informal conversations between federal agencies or private landowners and the FWS to determine whether activities will constitute adverse modification. Costs associated with technical assistance refer to the time and resources necessary for each of the parties concerned. During an actual consultation, communication between the parties may entail face-to-face meetings, letters, phone calls, or any combination of these. An informal consultation does not entail a biological assessment of the project, but is designed to identify and resolve potential adverse effects early on. However, if the issues and concerns of all parties involved cannot be resolved, a formal consultation must be undertaken. A formal consultation typically requires more effort on behalf of all involved, and generally necessitates a biological assessment of the project to study the potential effects of the project under question.

2) How much does a Section 7 consultation cost?

The cost estimates of Section 7 consultations used by EPS are presented in Table 4. EPS analysts assume that technical assistance only involves the FWS and the non federal government entity attempting to undertake the project. An informal consultation involves the federal nexus agency, and requires more time and effort on the part of all involved. A formal consultation requires a biological assessment and even more time and effort on behalf of all involved; this is reflected in its estimated costs.

Table 4
EPS Estimates of Cost per Consultation

Category	Technical Assistance		Informal Consultation		Formal Consultation	
	low	high	low	high	low	high
USFWS	\$260	\$680	\$1,000	\$3,100	\$3,100	\$6,100
Federal Agency	\$0	\$0	\$1,300	\$3,900	\$3,900	\$6,500
Third Party	\$600	\$1,500	\$1,200	\$2,900	\$2,900	\$4,100
Biological Assessment	\$0	\$0	\$0	\$4,000	\$4,000	\$5,600

3) How many consultations will occur?

To estimate the number of consultations that are expected to occur, EPS analysts consulted with the federal agencies that will be involved in each type of federal nexus. However, to estimate the number of consultations associated with private landowners, EPS relied on its estimates of development from the California Urban and Biodiversity Analysis model. They combined the estimates of total development with historical data concerning the size of an average consultation project provided by the FWS to determine the total number of each type of consultation. Their estimates are provided in Table 5.

Table 5

EPS Estimates of Numbers of Section 7 Consultations

Consultation Nexus Project Owner	Consultation Description					
	Technical Assistance	Informal Consultations	3rd Party Informals	Formal Consultations	3rd Party Formals	Biological Assessments
Department of Defense	0	16	0	20	0	20
State and Local Governments	0	400	400	21	30	21
Public and Private Entities	20	3	1	13	5	13
Public and Private Utilities; Energy	20	15	4	5	5	5
Western Area Power Administration	0	4	0	4	0	4
Bureau of Reclamation	0	34	0	41	0	41
Native American Governments	0	0	0	13	7	13
Private Landowners	173	208	208	69	69	69
Fish and Wildlife Service	0	11	0	11	0	11
Forest Service	0	25	0	31	0	31
Total	213	716	613	228	116	228

These estimates can be combined with the cost-per-consultation estimates to calculate the total cost for each type of consultation, as seen below in Table 6.

Table 6

EPS Estimates of Total Consultation Costs

Category	Technical Assistance		Informal Consultation		Formal Consultation		All Consultations	
	low	high	low	high	low	high	low	high
USFWS	\$55,380	\$144,840	\$716,000	\$2,219,600	\$706,800	\$1,390,800	\$1,478,180	\$3,755,240
Federal Agency	\$0	\$0	\$930,800	\$2,792,400	\$889,200	\$1,482,000	\$1,820,000	\$4,274,400
Third Party	\$127,800	\$319,500	\$735,600	\$1,777,700	\$336,400	\$475,600	\$1,199,800	\$2,572,800
Biological Assessment	\$0	\$0	\$0	\$0	\$912,000	\$1,276,800	\$912,000	\$1,276,800
Total	\$183,180	\$464,340	\$2,382,400	\$6,789,700	\$2,844,400	\$4,625,200	\$5,409,980	\$11,879,240

The largest part of the total costs due to critical habitat designation lies in the modification of projects to gain approval from the FWS; over 90% of the total costs are

expected to be due to project modifications. The largest portion of the costs are also shown to be borne by private landowners, and state and local governments, whose combined project modifications and administrative costs account for over 95% of the total costs of critical habitat designation.

Comparison of EPS Method with the Framework

The EPS analysis considers only a subset of the impacts described in our method presented in Section II. Table 7 below compares the categories of cost considered in the EPS report and this one (SSZ). Major categories of impacts ignored by EPS include consumer costs, delay costs and regional and indirect costs stemming from factors such as increased commute times, congestion, sprawl and regional job losses.

The EPS method assumes that all losses from CHD can be expressed as a percentage reduction in land value, which is then multiplied by county-average prices for developed land to obtain total county losses from CHD. This method, while transparent, is very likely to underestimate impacts for several reasons. Most important, EPS' method assumes that losses from CHD are capitalized into the price of land and borne entirely by landowners. For this assumption to be true, developers would have to earn no economic profits from their activities – which is, of course, false. In fact, profits from development are divided between landowners and developers since both provide needed inputs into the land development process.

Table 7

Comparison of Factors Considered by EPS and SSZ Methods

<i>EPS</i>	<i>SSZ</i>
Development cost increases	Development cost increases
Reductions in scale	Reductions in scale
No price effects	Price effects considered
All losses capitalized into land prices and borne by landowners	Distinguish among losses to consumers, developers, landowners and third parties
No delay costs	Delay costs considered
No regional or indirect effects	Third-party costs (e.g., congestion, sprawl and regional economic effects) are considered

To gauge the significance of EPS' decision to ignore these types of impacts, we have prepared a detailed simulation and calculated economic impacts to various groups using our method and that used by EPS in its vernal pool study. Not surprisingly, the total economic impacts of CHD are much larger when all effects are considered.

Tables 8a and 8b present the results of a variety of simulations designed to show the effects of varying some basic parameters on the impacts of CHD, and on the error resulting from use of the EPS method. The "Base Case" scenario in column one envisions a 1,000-unit housing project that is reduced to 800 units as a result of CHD. The demand for the project's units is given by the demand intercept and slope (we are using a linear framework), which give an implied demand elasticity of -1.67 evaluated at the initial price and quantity. The pre-regulation cost of development and construction is \$200,000 per unit (that is, we are taking marginal cost as constant), and CHD adds \$10,000 to the price of each unit. The rate of interest is 10 percent, and CHD is assumed to delay completion of the project by 1 year. The regional and indirect effects of not building the house (and having individuals commuting in from other areas) are \$5,000 per unit; these

incorporate avoided congestion costs, employment and productivity benefits, and reduced sprawl and pollution.

Before designation of critical habitat, the equilibrium price of each house in the development is \$250,000 and 1,000 units are sold. CHD increases the price of a house to \$280,000, and decreases output by 200 units. The increase in price and the reduction in the number of homes built cause a loss to consumers with a present value of \$27 million. The effects on producers are subtler. While producers lose from the reduction in quantity and the increase in development and construction costs, they also gain from the increase in selling price. In this base case, producers (including landowners) actually receive a net gain from CHD of \$6 million. We should note that in Scenarios 2 through 5, producers suffer a net loss from CHD. Taking these effects together, in Scenario 1 social surplus (or consumer plus producer surplus) decreases by \$21 million as a result of designation.

It is important to remember that, while landowners as a group can gain slightly in some scenarios, the CHD process poses significant risks for landowners. If a landowner's property is excluded from critical habitat while her neighbors' properties are included, then she stands to gain from the regulation. However, the value of the property *actually included* in the designation goes down. Viewed this way, CHD is a lottery that creates winners and losers, and imposes risks that landowners would rather avoid.

Another general point regarding this scenario is that it assumes the price of output (i.e., housing in this example) changes as a result of CHD. While this assumption is valid for residential and commercial development, it may not be as applicable to other industries. In agriculture, for example, many farmers sell their crops on world markets where price is essentially exogenous to production conditions in a given region. In this

case, the demand elasticity is very large and all losses are borne by the producer and the landowner. Consumers are not much effected in this case because the price of output does not change as a result of CHD.

Turning to the notion of delay cost, remember that the surplus losses discussed to this point are present-value losses from a *permanent* reduction in output, consumption and production. By contrast, the effects of delay are *temporary*. While social surplus loss stems largely from a reduction in output, delay cost stems from postponing construction of the units that *do* get built plus regional and indirect costs. Thus, as described above in Section II, delay costs are equal to post-construction consumer and producer surplus plus external costs multiplied by the interest rate for each period of delay.

Taking short- and long-run effects together, Scenario 1 shows that the total economic impact of CHD is \$33 million for this hypothetical project. The largest losers are consumers. Delay costs account for over one-third of total impacts.

Table 8a**Simulation Scenarios**

	<i>Scenario 1 Base Case</i>	<i>Scenario 2</i>	<i>Scenario 3</i>	<i>Scenario 4</i>
<i>Pre-CHD Output (Q0)</i>	1,000	1,000	1,000	900
<i>Post-CHD Output (Q1)</i>	800	800	800	800
<i>Demand Intercept</i>	400,000	400,000	350,000	350,000
<i>Demand Slope</i>	150	100	100	100
<i>Pre-CHD Marginal Cost (MC0)</i>	200,000	200,000	200,000	200,000
<i>Post-CHD Marginal Cost (MC1)</i>	210,000	210,000	210,000	210,000
<i>Implied Demand Elasticity</i>	1.67	3.00	2.50	2.89
<i>Interest Rate</i>	0.10	0.10	0.10	0.10
<i>External Cost per Unit</i>	5,000	5,000	5,000	5,000
<i>Periods of Delay</i>	1	1	1	1
<i>External Costs: Short-run</i>	5,000,000	5,000,000	5,000,000	4,500,000
<i>External Costs: Long-run</i>	1,000,000	1,000,000	1,000,000	500,000
<i>Pre-CHD Price (P0)</i>	250,000	300,000	250,000	260,000
<i>Post-CHD Price (P1)</i>	280,000	320,000	270,000	270,000
<i>Pre-CHD Consumer Surplus (CS0)</i>	75,000,000	50,000,000	50,000,000	40,500,000
<i>Post-CHD Consumer Surplus (CS1)</i>	48,000,000	32,000,000	32,000,000	32,000,000
<i>Pre-CHD Profit (PS0)</i>	50,000,000	100,000,000	50,000,000	54,000,000
<i>Post-CHD Profit (PS1)</i>	56,000,000	88,000,000	48,000,000	48,000,000
<i>Pre-CHD Social Surplus (SS0)</i>	125,000,000	150,000,000	100,000,000	94,500,000
<i>Post-CHD Social Surplus (SS1)</i>	104,000,000	120,000,000	80,000,000	80,000,000
<i>Extra Production Cost</i>	8,000,000	8,000,000	8,000,000	8,000,000
<i>Loss of Original Surplus</i>	13,000,000	22,000,000	12,000,000	6,500,000
<i>Surplus Loss: Long-run</i>	22,000,000	31,000,000	21,000,000	15,000,000
<i>Surplus Loss: Short-run</i>	13,000,000	15,500,000	10,500,000	9,900,000
<i>Losses from CHD</i>	33,000,000	43,681,818	29,590,909	23,536,364
<i>EPS Method</i>	4,259,167	4,259,167	4,259,167	2,129,584
<i>Ratio</i>	7.75	10.26	6.95	11.05

Table 8b**Simulation Scenarios**

	<i>Scenario 5</i>	<i>Scenario 6</i>	<i>Scenario 7</i>	<i>Scenario 8</i>	<i>Scenario 9</i>
<i>Pre-CHD Output (Q0)</i>	1,000	1,000	1,000	1,000	1,000
<i>Post-CHD Output (Q1)</i>	900	800	800	800	800
<i>Demand Intercept</i>	350,000	400,000	400,000	400,000	400,000
<i>Demand Slope</i>	100	150	150	150	150
<i>Pre-CHD Marginal Cost (MC0)</i>	200,000	200,000	200,000	200,000	200,000
<i>Post-CHD Marginal Cost (MC1)</i>	210,000	210,000	210,000	210,000	210,000
<i>Implied Demand Elasticity</i>	2.50	1.67	1.67	1.67	1.67
<i>Interest Rate</i>	0.10	0.10	0.125	0.10	0.10
<i>External Cost per Unit</i>	5,000	10,000	5,000	5,000	5,000
<i>Periods of Delay</i>	1	1	1	2	3
<i>External Costs: Short-run</i>	5,000,000	10,000,000	5,000,000	5,000,000	5,000,000
<i>External Costs: Long-run</i>	500,000	2,000,000	1,000,000	1,000,000	1,000,000
<i>Pre-CHD Price (P0)</i>	250,000	250,000	250,000	250,000	250,000
<i>Post-CHD Price (P1)</i>	260,000	280,000	280,000	280,000	280,000
<i>Pre-CHD Consumer Surplus (CS0)</i>	50,000,000	75,000,000	75,000,000	75,000,000	75,000,000
<i>Post-CHD Consumer Surplus (CS1)</i>	40,500,000	48,000,000	48,000,000	48,000,000	48,000,000
<i>Pre-CHD Profit (PS0)</i>	50,000,000	50,000,000	50,000,000	50,000,000	50,000,000
<i>Post-CHD Profit (PS1)</i>	45,000,000	56,000,000	56,000,000	56,000,000	56,000,000
<i>Pre-CHD Social Surplus (SS0)</i>	100,000,000	125,000,000	125,000,000	125,000,000	125,000,000
<i>Post-CHD Social Surplus (SS1)</i>	85,500,000	104,000,000	104,000,000	104,000,000	104,000,000
<i>Extra Production Cost</i>	9,000,000	8,000,000	8,000,000	8,000,000	8,000,000
<i>Loss of Original Surplus</i>	5,500,000	13,000,000	13,000,000	13,000,000	13,000,000
<i>Surplus Loss: Long-run</i>	15,000,000	23,000,000	22,000,000	22,000,000	22,000,000
<i>Surplus Loss: Short-run</i>	10,500,000	13,500,000	16,250,000	26,000,000	39,000,000
<i>Losses from CHD</i>	24,136,364	34,409,091	35,805,556	46,000,000	59,000,000
<i>EPS Method</i>	2,129,584	4,259,167	4,259,167	4,259,167	4,259,167
<i>Ratio</i>	11.33	8.08	8.41	10.80	13.85

It is possible to compare impacts measured by this method against the one used by EPS. To summarize, the EPS method involves multiplying acres of critical habitat by a percentage loss in land value (conditional on the type of habitat) and then by an assumed land price. In Scenario 1, we are assuming a 20 percent reduction in units constructed. To map this into the EPS method, we assume that 20 percent of the land in the project is declared off-limits to construction due to the presence of vernal pools (thus, we posit no change in the density of development). We make the conservative assumption that the land declared off-limits is the most sensitive type: Group B Critical Habitat. EPS uses a figure of 86 percent loss in land value for this type of habitat. With regard to land price, we assume conservatively that the price is the highest among all California counties considered by EPS: \$123,813 for Monterey County.

Multiplying these figures together, the EPS method predicts that CHD will have economic impacts of \$4.3 million. All of these losses are assumed to be borne by the landowner – developers, homebuyers and others in the region are assumed to be entirely unaffected. Interestingly, our model shows that landowners are actually among the groups *least* affected by designation of critical habitat. If the effect of CHD is to restrict supply and drive up the price of output (such as housing or commercial development), then landowners can actually gain from the regulation since developable land has become scarcer. In cases such as agriculture where the price of output may not change as a result of designation of critical habitat, then CHD does not affect consumers and all impacts are borne by producers and landowners. With regard to total impacts rather than their incidence, comparing the EPS method to the one developed in this paper, we see that EPS understates the true economic impacts of CHD by a factor of 7.75 in this scenario.

Other scenarios in Table 8 vary the key parameters of the simulation. Scenario 2 varies the position of the demand curve, making it more elastic (smaller price effect) but positioned above the demand curve in Scenario 1. Scenario 3 retains the more elastic demand curve of Scenario 2, but lowers the intercept (thereby reducing consumers' willingness to pay for housing).

Scenarios 4 and 5 consider a case where CHD only reduces the size of the housing project by 100 units. For comparison purposes, we assume that the amount of land set aside under the EPS method decreases proportionally. Scenario 6 varies the external or regional cost of a reduction in the stock of housing from \$5,000 to \$10,000. Scenario 7 considers the effect of a change in the rate of interest, and Scenarios 8 and 9 consider the effect of increasing the period of delay in completing the project. The effects of delay are again shown to be large. Increasing delay from one to three years increases total impacts of CHD from \$33 to \$59 million. Of course, the EPS assessment is unaffected by delay and stays constant at \$4.3 million.

The overall lesson from these simulations is that, comparing our method to the EPS approach head-to-head, the actual economic impacts of CHD are from 7 to 14 times higher than one would calculate using the EPS method. Further, the EPS approach badly misses the mark when considering which groups bear the brunt of the impacts. Our approach shows that, when the price of output is affected by CHD, economic impacts are borne disproportionately by consumers, whereas the EPS approach holds that all impacts of CHD are borne by landowners.

V. Conclusions

It is widely recognized that critical habitat designation can cause economic impacts due to the effects of designation on project size and on costs of development. The process of land development is conditioned by numerous factors in addition to federal environmental regulation, including local regulation, topography, location of infrastructure, location of businesses and other factors. If critical habitat designation reduces the scale of projects, delays their completion or even increases the cost of development and construction, then the price of the project output may be affected.

This paper draws on stylized facts about the land development process to formulate an economic model of the impacts of critical habitat designation. The model captures a range of potential impacts, and can be compared to the approach taken by USFWS consultants charged with measuring the economic impacts of designation. The approach taken by Economic and Planning Systems to estimate the impacts of critical habitat designation for vernal pools in California is to calculate the economic costs of designation on a per acre basis and then assume that all of these costs are capitalized into the price of land. As a result, their analysis assumes that landowners alone bear the costs of critical habitat designation, and that the costs of designation are strictly proportional to the average price of developable land.

The model we develop for measuring the economic impacts of critical habitat designation takes a more general approach. We allow for the possibility that designation can increase development costs and reduce the size of planned projects. We also allow for the possibility that impacts may be borne by consumers as well as developers and

landowners. Our model incorporates economic impacts resulting from project delay, which can affect all groups.

After detailing the approach taken by Economic and Planning Systems to estimate the impacts of critical habitat designation for vernal pools, we compare their approach to our more general model using some common parameters. One conclusion of the simulation analysis is that the Economic and Planning Systems method underestimates actual economic impacts by 7 to 14 times, depending on the scenario considered. Further, by attributing all costs to landowners, the Economic and Planning Systems method seriously misstates the distribution of economic impacts among groups in society. In fact, under reasonable conditions, consumers are expected to bear the brunt of the economic costs of habitat designation, and landowners and developers' costs can be mitigated to some degree by the output price increases resulting from designation.

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Appendix

This Appendix shows the necessary calculations to derive the Percentage Reduction in Land Values from Step 5.

Assumptions:

- 1) 25% of areas to be developed are for public uses: roads, parks, schools, and other infrastructure, which means this acreage is not available for private development.
- 2) Vernal pools occur on 3.5% of all critical habitat land.
- 3) The cost per acre of conservation credits/off-site lands for preserving vernal pools is 48% of the price of privately developed land in the county.
- 4) The cost per acre of restoring vernal pools is 12% of the price of privately developed land in the county.

Let L be the total number of acres slated for development, and P be the price of developed land facing the developer. The Potential Project Value facing the developer is equal to $L * P * .75$ (since only 75% is available for private development).

We can compare the value of the land after regulation to this potential value to determine the Percent Value Lost.

Group A Critical Habitat:

For projects in Group A, EPS assumes that the regulatory restrictions facing the developer are as follows. Vernal Pool acres that are filled must be preserved on an off-site location at a ratio of 2:1. The developer will fill the 3.5% of the land containing vernal pools, which means the developer must purchase a number of preservation credits

equal to $.07 * L$. The cost to the developer per acre is equal to $.48 * P$, making the total cost equal to $.7 * L * .48 * P = L * P * .0336$. Therefore, the Percentage Value Lost is equal to the total cost of regulation divided by the Potential Project Value. This is equal to $\frac{TC}{PPV} = \frac{L * P * .0366}{L * P * .75} = .0448 = 4.48\%$. The developer loses 4.48% on each acre of land that he wants to develop.

Group B Critical Habitat

For projects in Group B, EPS assumes that the regulatory restrictions facing a developer are as follows. The developer must avoid six acres for every developed acre. Also, developers must restore three acres for every acre of vernal pool that are filled. This limits the developer to one-seventh of the total project area, which automatically costs the developer $\$ \frac{6}{7} * \left(L * P * \frac{3}{4} \right)$. It also means that only $L * .035 * 1/7$ acres of vernal pool will be filled, requiring a restoration cost of $.12 * P$ dollars per acre. The Total Cost to the developer then, is the sum of the value of the acres not available for development and the cost of pool restoration, $\frac{6}{7} * \left(L * P * \frac{3}{4} \right) + \left(.035 * L * \frac{1}{7} * 3 \right) * (.12 * P)$. The

Total Cost of regulation divided by the Potential Project Value will again yield the Percentage Value Lost,

$$\frac{\frac{6}{7} * \left(L * P * \frac{3}{4} \right) + \left(.035 * L * \frac{1}{7} * 3 \right) * (.12 * P)}{L * P * \frac{3}{4}} = \frac{6}{7} + .035 * \frac{4}{7} * .12 = .8595 = 85.95\%$$

The developer loses 85.95% of the potential land value.